INTRODUCTION TO COGNITIVE NEUROPSYCHOLOGY

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SHOUT
SHARE
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WHAT IS NEUROPSYCHOLOGY?

- *Neuropsychology* is the study of the effects of lesions or dysfunctions of the Central Nervous System (CNS) on cognition and behaviour.

- The regions of interest are the cortex of the two brain hemispheres, the sub-cortical structures (such as thalamus, basal ganglia, hypothalamus, and amygdala) and the main connecting white matter fibres.

THE AIMS OF NP

- Neuropsychology is useful for both research and clinical purposes:

1. It explores the functional architecture of the mind and its neural correlates;

2. It provides patients with a diagnosis and possibly with rehabilitative recommendations.

- No research is possible without a clear understanding of the nature of the deficit.

LOCALIZATION

- The history of neuropsychology is linked to the changing of concepts of functions' *localization.*
- By *localization* we mean that different parts of the brain are specialized in such a way so as to contribute to behaviour at various levels.
- The most fundamental fact was established in ancient times when the Greeks first determined that the *brain* was the physical *seat* of the mind.
- The one credited with making this basic advance in the *V century* B.C. is Alcmaeon of Croton, who came to this conclusion after observing brain damaged patients.

THE CARDIOCENTRIC VIEW

- The alternative hypothesis held the *heart* to be the organ responsible for sensation and thought.

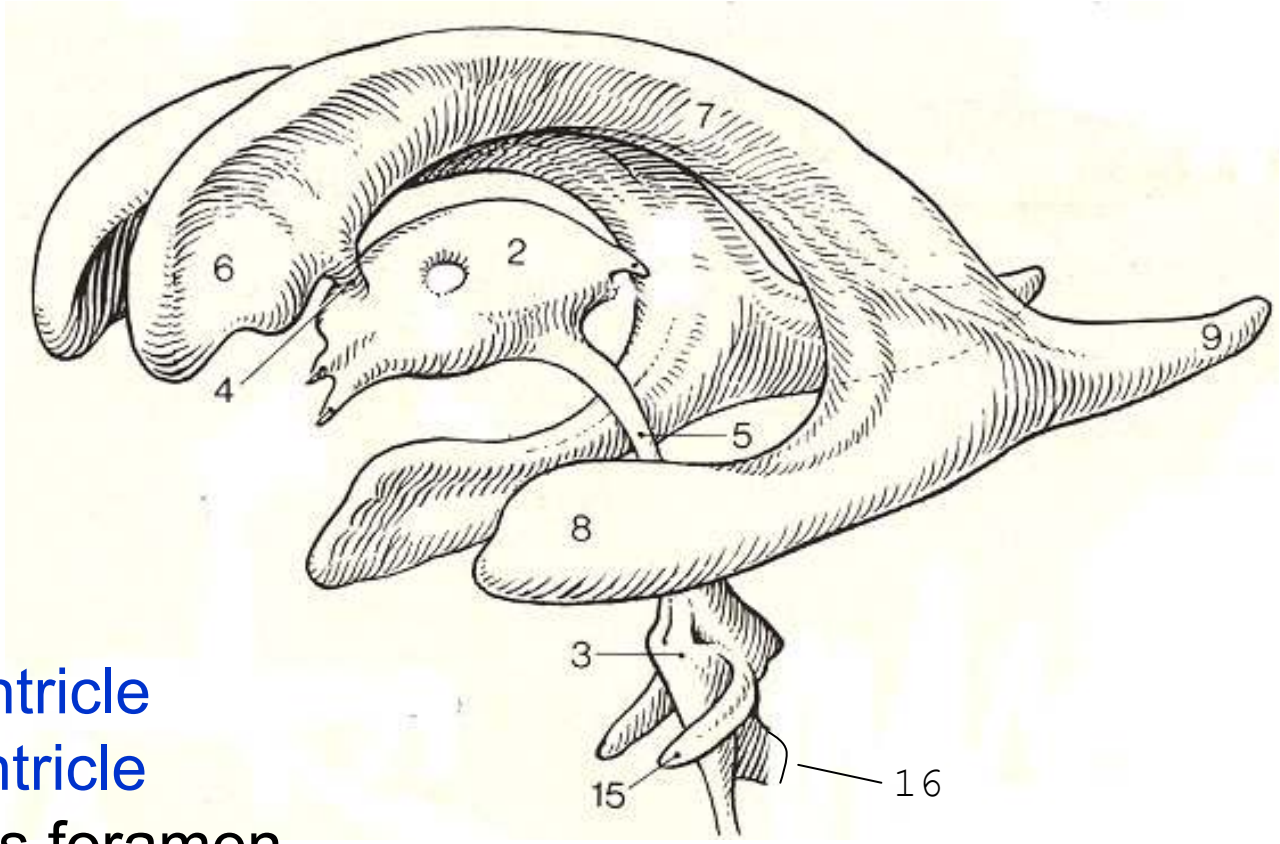
- This was the accepted view among ancient Egyptian writers and continued to attract adherents in ancient Greece.

- Among them, Aristotle (ca 384-322 BC) maintained the *cardiocentric view*, and suggested that the brain served to cool the blood.

THE THEORY OF THE VENTRICLES

- Among cerebrocentrics, however, the nature of the mind-brain relation was poorly understood.
- In fact, for centuries, the most important anatomical features of the brain were considered to be the *ventricles.*
- Why *ventricles?* Because they contained the *real substance* of the mind, i.e. the *cerebrospinal fluid.*

VENTRICLES



2: 3rd ventricle
3: 4th ventricle
4: Monro's foramen
5: aqueduct
6-9: lateral ventricles (1-2)
15: Luschka's foramen & (16) Magendie's foramen

LOCALIZATION AND THE VENTRICLES

Herophilus of Alexandria (ca 335-280 BC)

- placed the mind in the *posterior (fourth) ventricle.*

Galen (130-200 AD)

- distinguished three basic components of the intellect: ***imagination, reason and memory.***
- Although he thought that each function could be affected separately by brain damage, he did not propose to localize them within the ventricular system.

Nemesius Bishop of Emesia (ca. 390 AD)

- proposed that ***perception*** + ***imagination*** were localized in the 2 lateral ventricles (treated as a single, anterior cavity);
- ***reason*** in the middle ventricle (3°);
- ***memory*** in the most posterior ventricle (4°).

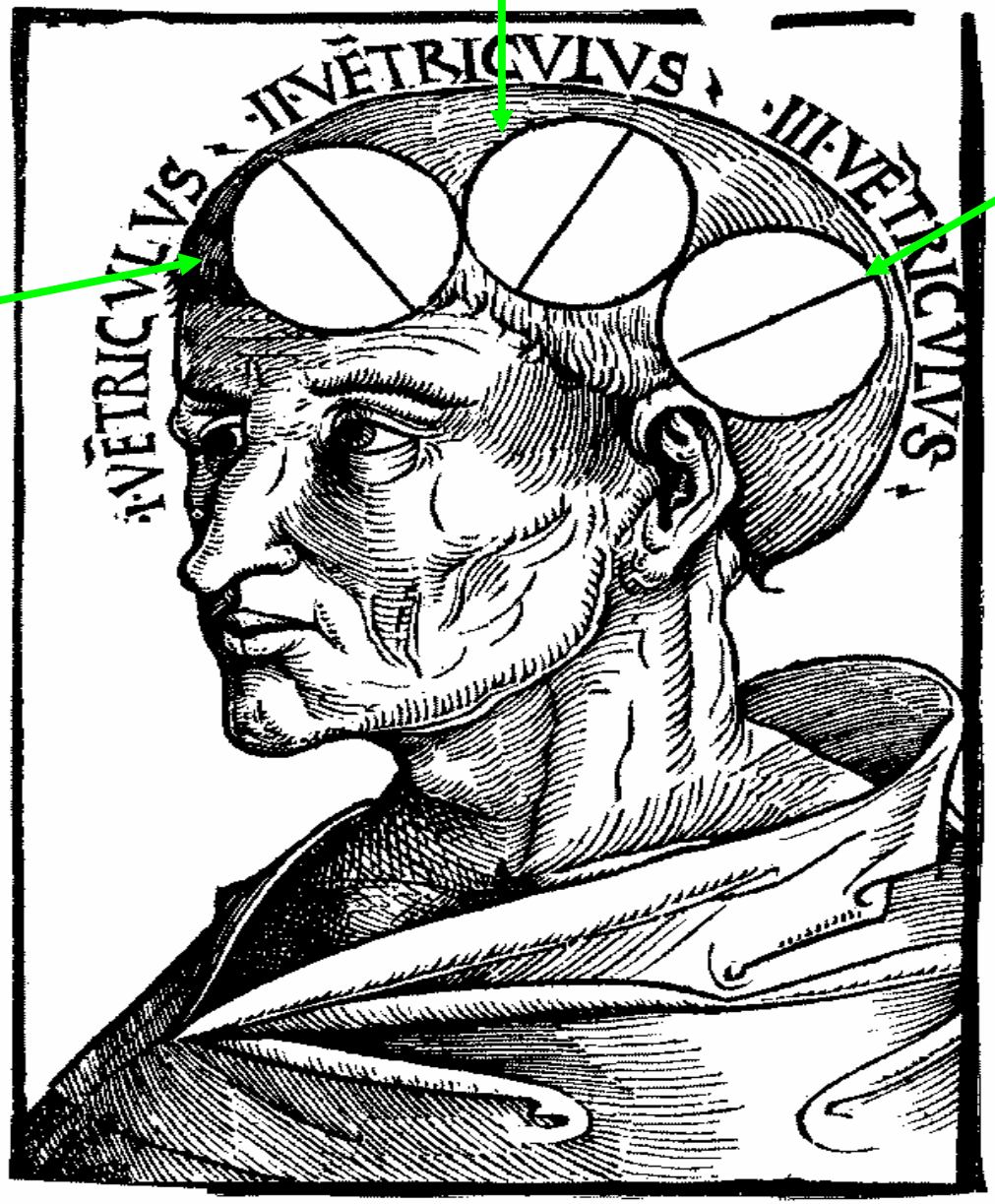
2nd Ventricle

Reason

1st Ventricle

Perception

Imagination



3rd Ventricle

Memory

Albertus Magnus, *Philosophia naturalis*, 1506

DECLINE OF THE THEORY OF THE VENTRICLES

- After many centuries, the ventricular doctrine slowly started to decline and the forebrain began its rise to prominence as the source of things intellectual.

WHITE MATTER

- After the XVI century, it was accepted that the encephalon was the site of mental functions but the critical structure was held to be the *white matter*, whereas the *gray matter* was considered as the external, protecting layer.

- Schenck (XVI)
- Wepfer (1727, book published posthumously)

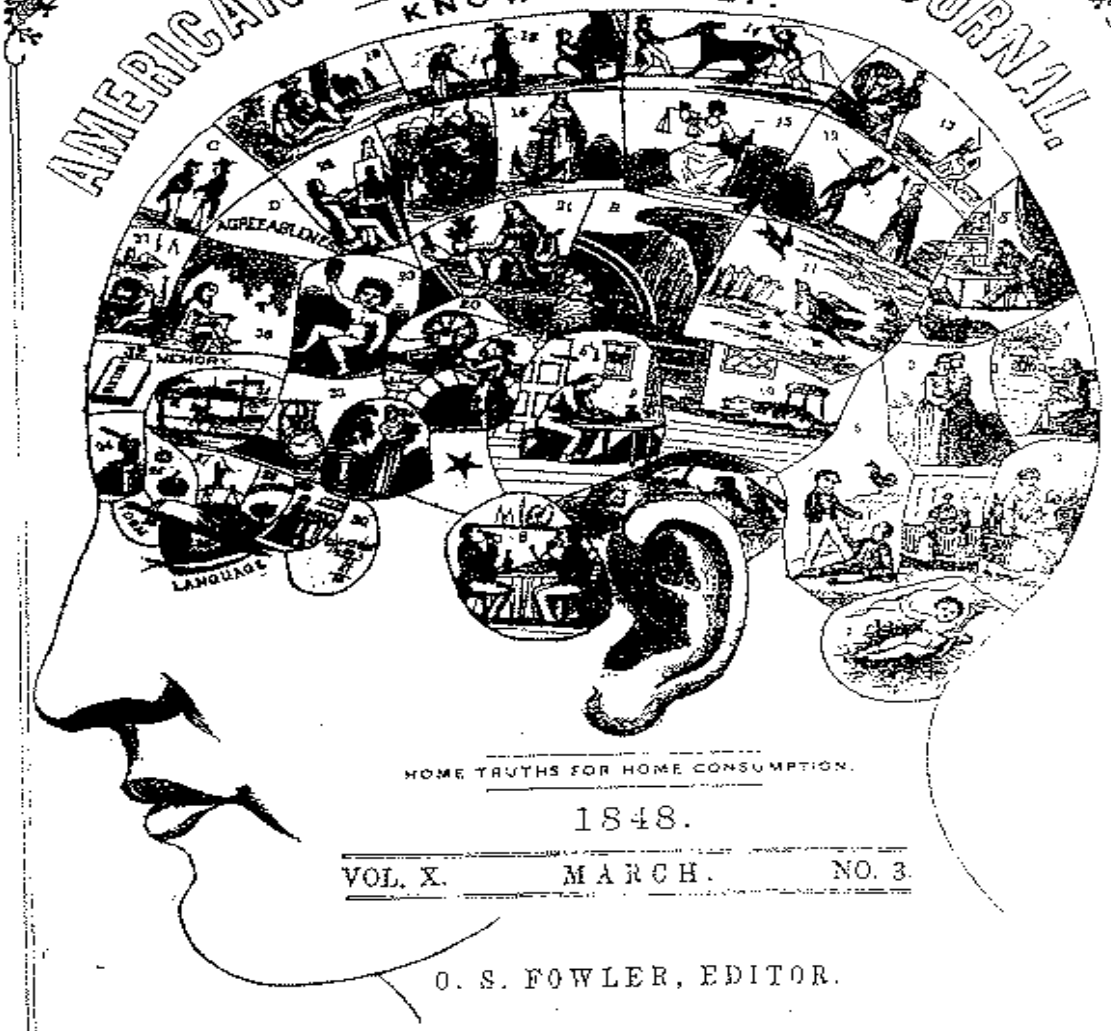
RISE OF THE THEORY OF PHRENOLOGY

FRANZ JOSEPH GALL (1757-1828)

- He proposed an explicit theory of the mind-brain relationship whose main ideas are:
  - the mind is made up of 27 distinctive components (*faculties*)
  - these are localized in specific regions (*organs*) of the cerebral cortex
  - the amount of a given faculty determines the size of the organ: the more highly a faculty is developed, the larger the organ.
  - by measuring the skull of an individual, one can infer the dimension of single faculties.

AMERICAN PHRENOLOGICAL JOURNAL.

KNOW THYSELF.



HOME TRUTHS FOR HOME CONSUMPTION.

1848.

VOL. X. MARCH. NO. 3.

O. S. FOWLER, EDITOR.

PHRENOLOGY, PHYSIOLOGY, PHYSIOGNOMY, MAGNETISM.

NEW YORK:

FOWLERS & WELLS,

PHRENOLOGICAL CABINET, 131 NASSAU-STREET.

Terms $1 a Year, invariably in advance. Ten cts. a Number.

- The theory of phrenology was dismissed because it could not be proved scientifically:
  - too many faculties which were non-cognitive
  - impossible to find their localization.

- Although the method employed by Gall was far from being satisfactory, the theory had the merit of drawing the attention to the correlation between the *cortex (i.e. grey matter)* and *cognitive functions.*

- Importantly, Gall and his followers were convinced that speech was housed in the front part of the cerebral cortex.

IS LANGUAGE IN THE FRONTAL LOBES?

JEAN-BAPTISTE BOUILLAUD (1796-1881)

- examined a large number of patients with brain damage and language disorders (collected by others);
- confirmed the localization of speech in the frontal cortex, without distinguishing between left and right hemisphere, in all the cases considered.
- However Luzzatti & Whitaker (2001) demonstrated that Bouillaud's localization was inconsistent with the observation of many patients with injuries to the frontal lobes without aphasia (and patients with aphasia without frontal lesions).

IS THE LEFT HEMISPHERE SPECIALIZED FOR LANGUAGE?

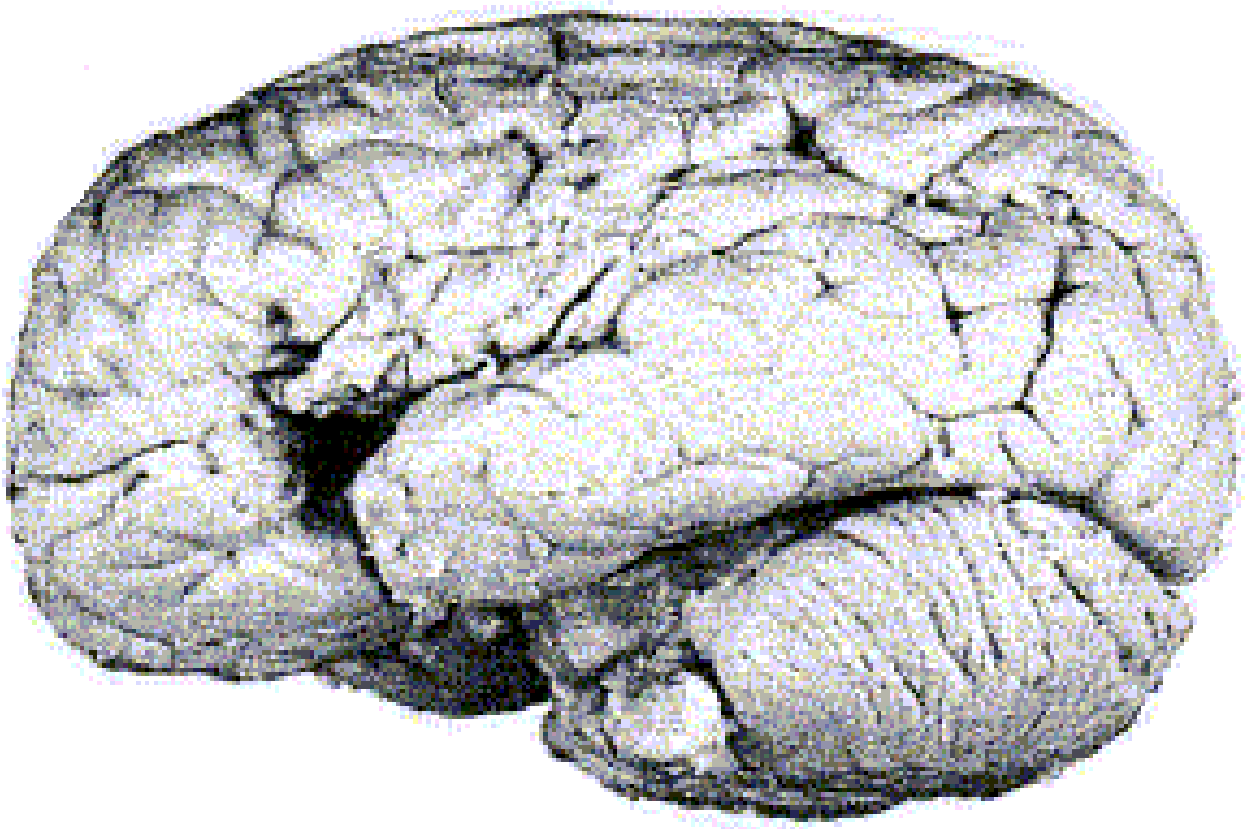
Marc Dax (1770-1837)

- In 1836, he presented at a conference of medicine in Montpellier, more than 40 cases of patients with left-hemisphere lesions and aphasia, suggesting that language is a lateralized function.
- Dax's report was published by his son only in 1865, after his death.

PAUL BROCA

- In 1861, he presented his celebrated case of Monsieur Leborgne, nicknamed "*Tan*" because this was his only utterance, along with a few obscenities.
- This 51-yr-old man was a long-term resident in an institution, who had lost his capacity for voluntary language 21 yrs. earlier, and had not been able to use his right arm for 10 yrs.

- Tan died soon after Broca saw him and his autopsy revealed a lesion centered in *the foot of the third frontal convolution of the left hemisphere.*

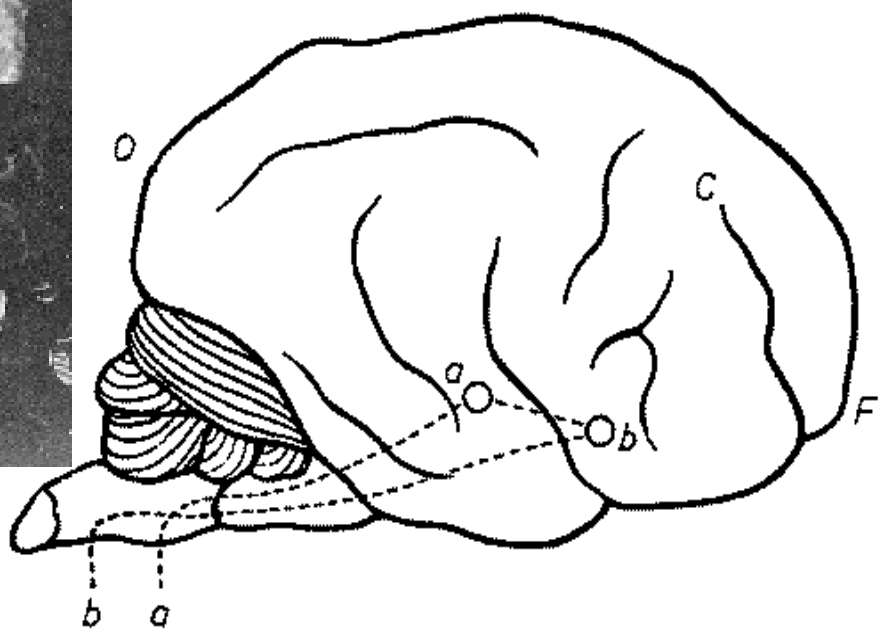


"Tan's" brain, now at the Musèe Dupuytren

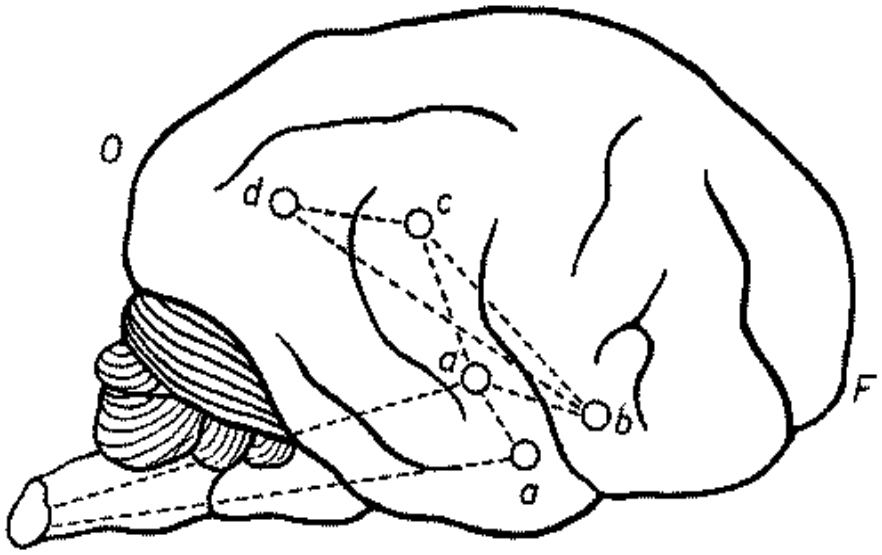
- In 1865, Broca suggested that language was a *function lateralized in the left hemisphere*.

Wernicke

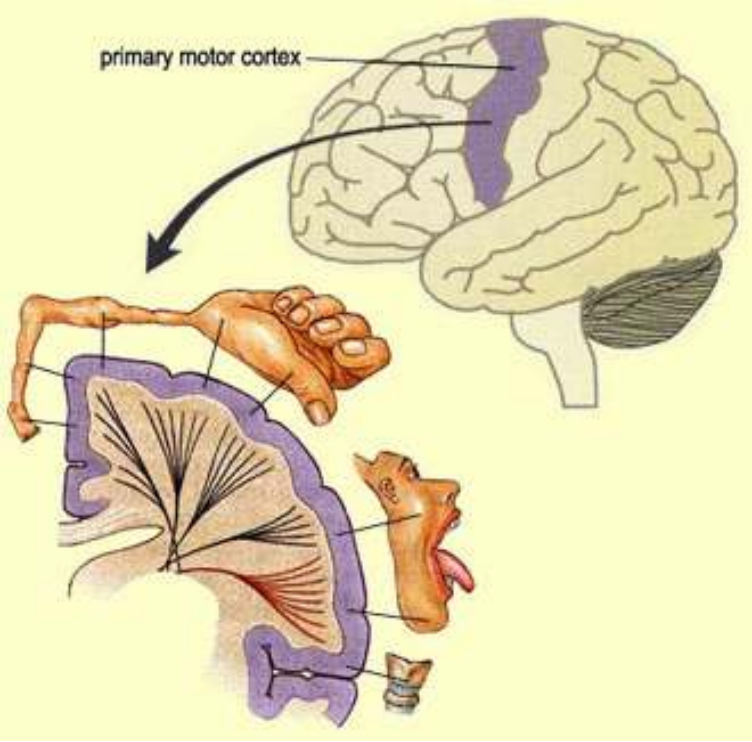
He proposed a general model (1874) of language that could explain a number of different aphasic syndromes by means of lesions to different centers and connections to centers.



Unlike Gall's model, a relatively small number of basic centers and connections allow one to explain a wide variety of higher functions.



Localizing motor functions



- Fritsch & Hitzig (1870) found that, depending on what part of the dog's cortex they stimulated electrically, a different part of the body contracted.
- They also found that if they destroyed this same small area of the cortex, the corresponding part of the body became paralyzed.
- They thus established that every part of the body has a particular region of the primary motor cortex that controls its movement.
- Body parts that can make the finest movements take up much more space than others (Penfield, in man).

- David Ferrier (1843-1928) performed electric stimulation on the monkey brain.

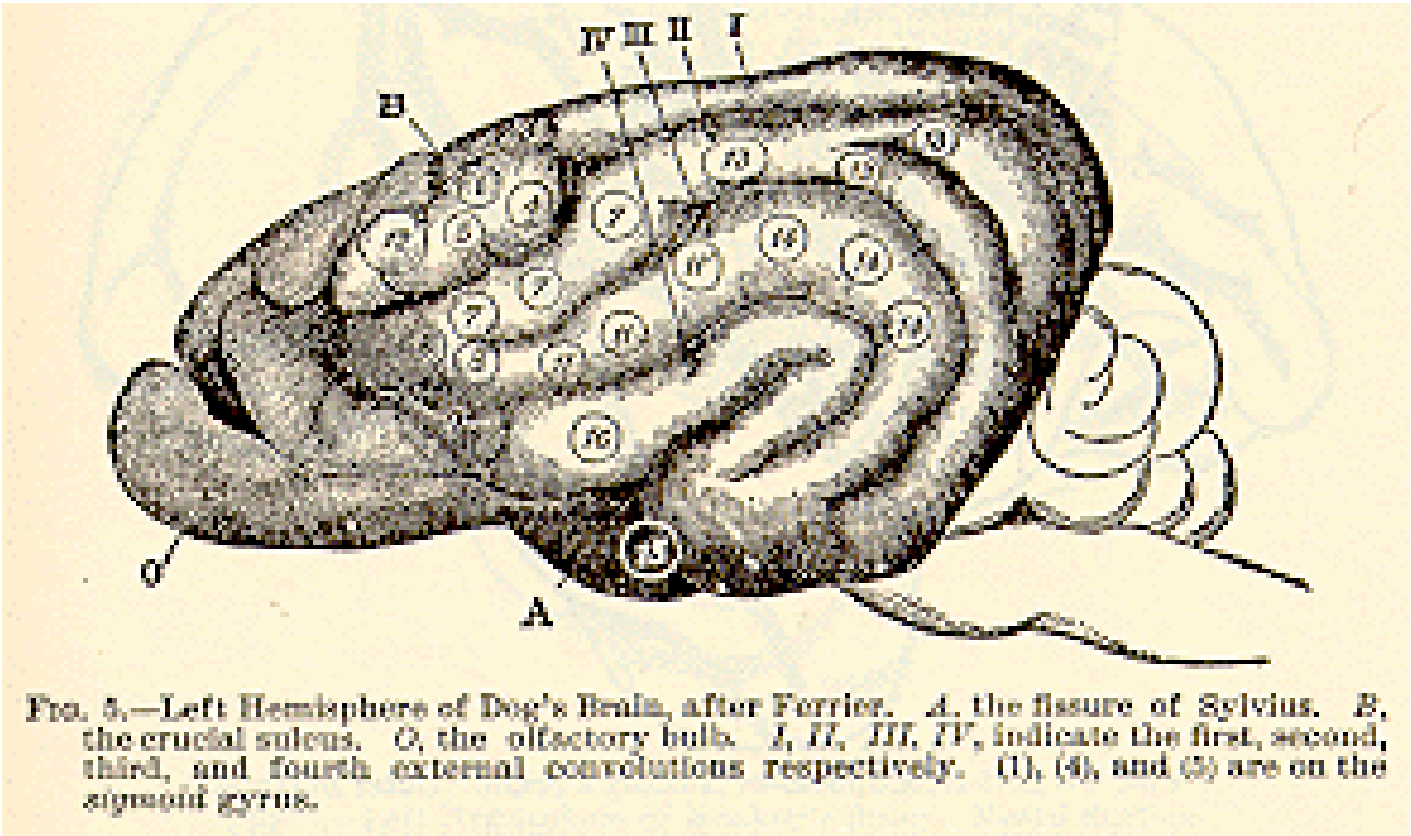
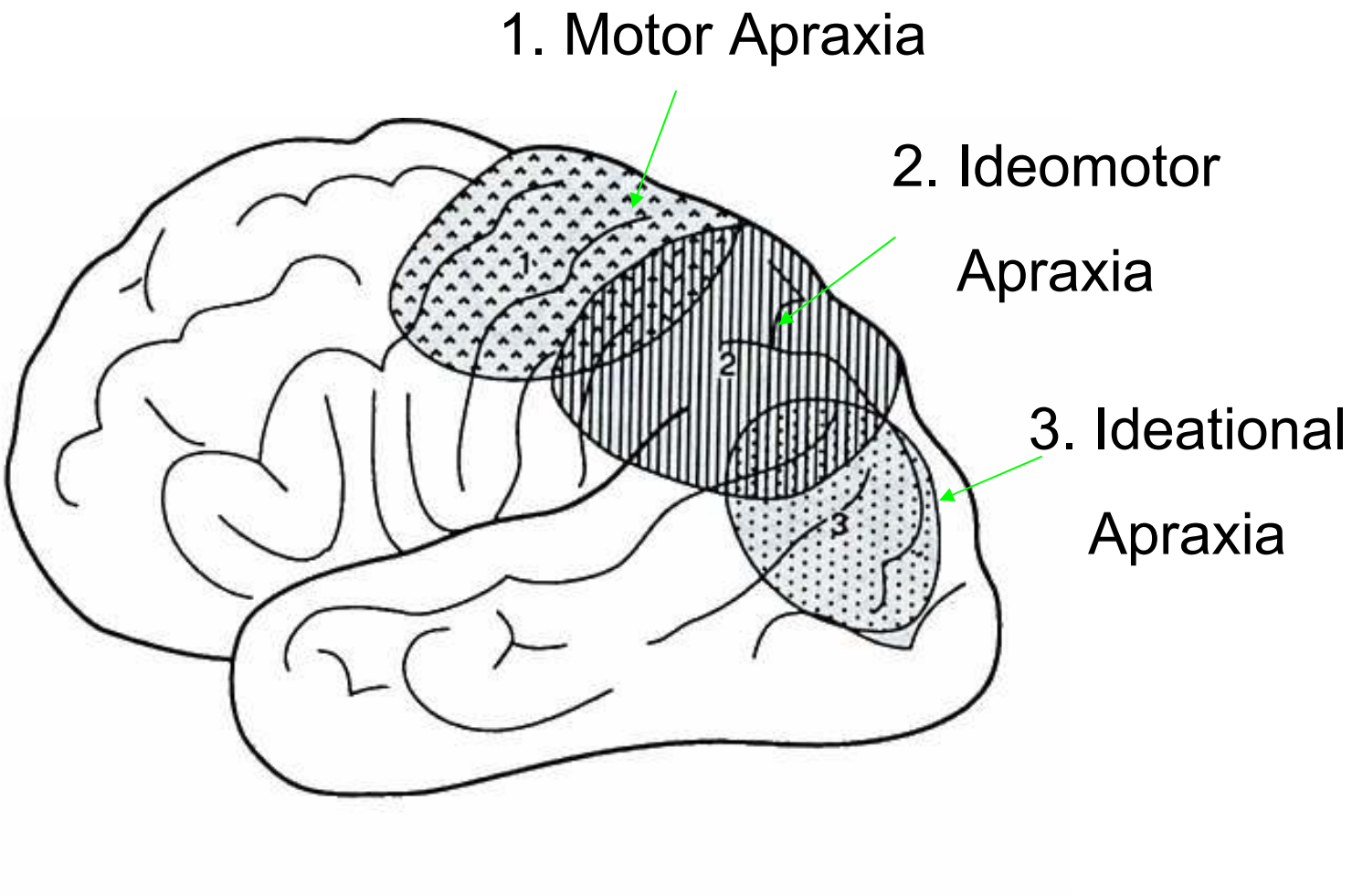


FIG. 5.—Left Hemisphere of Dog's Brain, after Ferrier. *A*, the fissure of Sylvius. *B*, the crucial sulcus. *O*, the olfactory bulb. *I, II, III, IV*, indicate the first, second, third, and fourth external convolutions respectively. (1), (4), and (5) are on the sigmoid gyrus.

APRAXIA: LIEPMANN (1920)



PSYCHIC BLINDNESS

- Munk ablated bilaterally the occipital lobes of dogs and monkeys (1878, 1881).
- The ablation produced an impairment of the animals' ability *to recognize objects,* although they were still able to navigate in the environment.
- These findings established an association between vision and occipital cortex.

Seelenblindheit or *Soul-blindness*

- Lissauer (1890) described the case of a patient with a lesion of the left temporo-occipital junction, who was not able to identify familiar objects though he could copy drawings and was not confused.

- He suggested a distinction between an *apperceptive* and an *associative* deficit, a clinical dichotomy still in use today.

- The term *agnosia* was introduced by Sigmund Freud (1891).

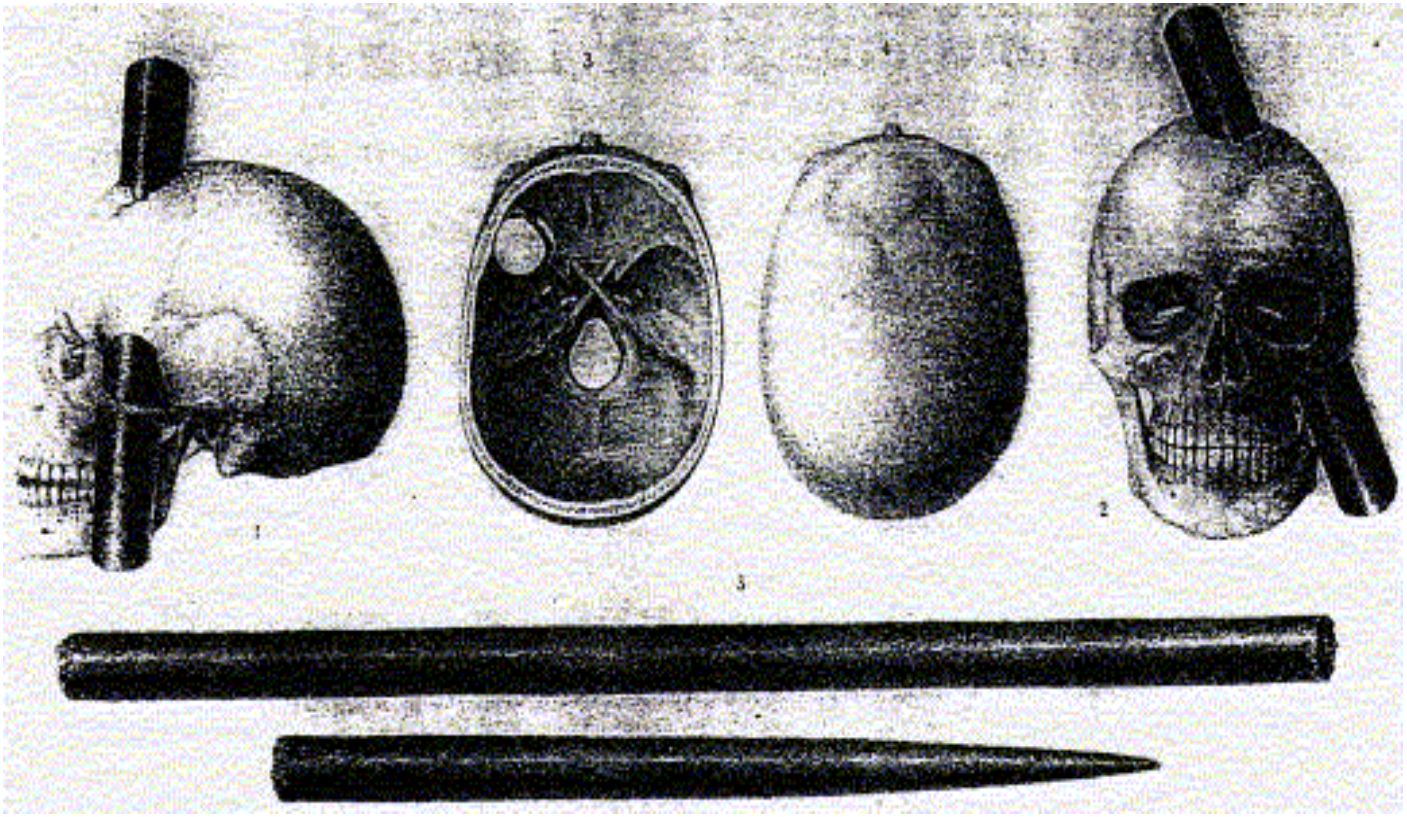
THE RIGHT HEMISPHERE

- The first to recognize that the right hemisphere might have specialized functions of its own was Hughlings Jackson (1876).

- Based on the clinical observation of a single patient, he argued that whilst the left hemisphere might be “dominant” for language, the right hemisphere was critical for visuo-perceptual abilities.

INTELLECT & FRONTAL LOBES

- Damage to prefrontal cortex leads to more complex phenomena.
- The first description of the consequences of lesion to these regions in man is that of Phineas Gage, given by Harlow in 1848.
- Gage was a rail-road foreman who accidentally dropped his tamping iron on a rock, igniting some blasting powder.
- The explosion caused the iron to shoot through the left side of Gage's jaw and up through the front of his cranium.



Harlow (1868)

CLINICAL REMARKS

"He was no longer Gage"

- Gage's recovery over the next few months after the accident was far better than anyone expected.
- However, it was clear that his personality and intellect had been altered:
  - he now exhibited poor judgment, impulsivity, and lack of restraint;
  - he had become childish.
- This was the beginning of the association between frontal lobes and more abstract intellectual functions.

LIMITS OF TRADITIONAL NP

- With a few exceptions, individual patients were poorly described.
- They often suffered from multiple deficits.
- Patients were grouped into *syndromes* because they shared symptoms (patients with Broca's aphasia, Wernicke's aphasia, etc.).
- The psychological concepts and tests available were inadequate.
- The techniques were too few.

DIAGRAMS

- Traditional neuropsychologists made a great use of diagrams between 1870 and 1910.
- These diagrams were used to explain different forms of language disorder in terms of damage either to the centres themselves or to the pathways connecting them.
- The best known is that put forward by Lichtheim (1885).

Lichtheim's Model

A = centre of auditory *representations of words*

B = centre of auditory *representations of words*

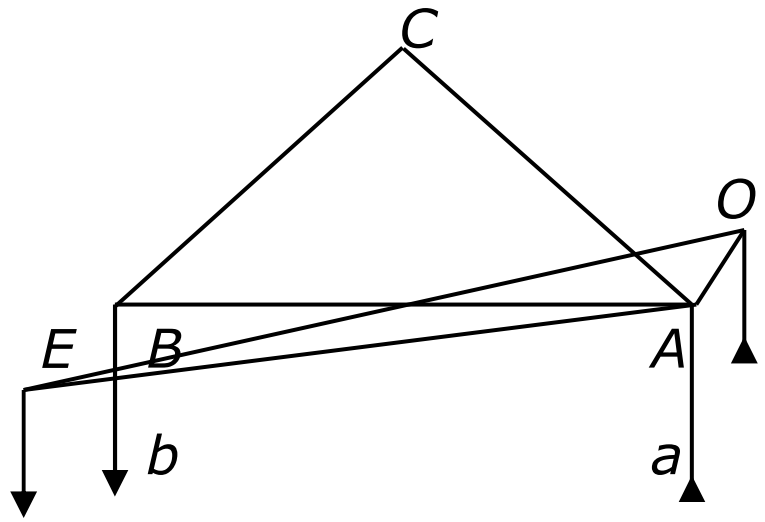
a = *auditory analysis*

b = *articulatory programming*

C = conceptual knowledge

O = *visual engrams* (reading)

E = *hand motor engrams* (spelling)



LIMITS OF DIAGRAMS

- They were only of real use in interpreting disorders that affected comprehension, production, repetition of single words.
- They had little to say about:
  - disorders affecting, for example, grammatical processes involved in sentence construction;
  - or about how the centres might actually work.
- They were constrained only by neuropsychological evidence and often changed to fit new patterns.
- Diagrams were super-imposed upon the left cerebral hemisphere of the brain:
  - they incorporated both a cognitive theory of what centres and connections are, and where they were located.

COGNITIVE NEUROPSYCHOLOGY

- A revolution occurred when patient-based neuropsychology and cognitive psychology eventually came together.
- The main tenet of cognitive psychology is that mental activity (i.e. cognition) is information processing.
- By varying stimuli and instructions to the subjects, and by measuring their responses, cognitive psychologists make inferences about the information processing that intervenes between stimulus and response (*the black box*).

COGNITIVE NEUROPSYCHOLOGISTS

- seek to explain the patterns of impaired and intact cognitive performance seen in brain-injured patients in terms of damage to one or more of the components of a theory of normal cognitive functioning

- and, on the other hand, to draw conclusions about normal, intact cognitive processes from observed disorders.